Appl. No. 10798528
Amdt. Dated May 10, 2005
Reply to Office action of 1/10/05

Amendments to the Specification:

Please replace paragraph; page 2, lines 7-9 with the following amended paragraph:

This application is a follow-on application to U.S. Provisional application Ser. No. ~~60/232,027~~ 60/323.027 filed 09/12/2001, and entitled "Improved Ships Hull Cleaning System." The contents of the aforementioned application are incorporated by reference herein.

Please replace the paragraph beginning on page 13 at line 6 with the following amended paragraph:

Turning now to Figs. 2 and 3, there are shown two exemplary embodiments of the brush head assembly **60** employed in the ship hull cleaning apparatus **10** of the present invention. Generally, the brush head assembly **60** includes a yoke **62** pivotably mounted on the free end **46** of the articulated arm **40**, at least one brush drum **64** rotatably mounted within the yoke **64** **62**~~, and a mechanical drive **66** (Fig. 4) installed on the yoke **64** in engaging relationship with the drum **64** so as to rotationally drive the drum **64** during cleaning~~. It will be appreciated that each drum **64** may be formed in a variety of shapes and from a number of materials known in the art to effectively remove any foreign objects from the ship hull **102** such as sea grasses, tubeworms, barnacles or the like. As such, it is to be understood that the finned, substantially cylindrical brush drums **64** shown and described are merely exemplary of the drums that can be employed in the cleaning apparatus **10** of the present invention. To further improve performance of the brush drums **64**, the drums **64** are configured within the yoke **62** ~~to~~ so that they may be rotated by ~~the~~ a mechanical drive **66** **(not shown)** in a direction opposite the direction of

travel of the entire brush head assembly **60** over the surface of the ship hull **102** (Fig. 1), or to counter-rotate, as explained more fully below. In the embodiment shown in Fig. 2, the yoke **62** is configured for mounting two brush drums **64** in a substantially parallel, spaced-apart arrangement. The yoke **62** includes a back plate **68** with parallel pairs of brackets **70** extending therefrom and between which the drums **64** are rotatably mounted. Functionally installed between the back plate **68** of the yoke **62** and the member **42** located at the free end **46** is a device such as a hydraulic cylinder **72** for dynamically pivoting the yoke **62** about the free end **46** of the articulated arm **40**. In this way, the cylinder **72** is operable to selectively pivot the yoke **62** such that the two brush drums **64** are substantially in contact with the ship hull **102** (Fig. 1) during cleaning. Where hydraulic cylinders are employed throughout the cleaning apparatus **10**, it will be appreciated that a common power source (not shown) such as a gasoline or diesel engine may be employed to generate the required hydraulic pressure for the hydraulic control systems, as is known in the art. As with the hydraulic cylinders **48** employed in the exemplary embodiment of the articulated arm **40**, it will be further appreciated that a number of other dynamic pivoting mechanisms other than the hydraulic cylinder **72** shown and described, such as a hydraulic ram, a hydraulic motor, a pneumatic cylinder, a pneumatic ram, a pneumatic motor, or an electric motor, may be employed in selectively pivoting the yoke **62** to optimally position the brush drums **64** against the ship hull **102** (Fig. 1). In the alternative embodiment of the brush head assembly **60'** shown in Fig. 3, the yoke **62'** is configured with opposing foot plates **70'** that are substantially triangular in shape and between which are rotatably mounted three brush drums **64'** substantially at the respective corners of the foot plates **70'** and in a substantially parallel, spaced-apart arrangement. The yoke **62'** is mounted on the free end **46'** of the articulated arm **40'** so as to pivot substantially about the centers of the respective foot plates **70'**. Because the yoke ~~42'~~ **62'** is freely pivotable about the free end **46'** of the member **42'**, it will be appreciated by those skilled in the art that two of the three brush drums **64'** will be substantially in contact with the ship hull **102** (Fig. 1) when the brush head assembly **60'** is positioned against the hull during cleaning. It will be further appreciated that other

combinations of yokes and brush drums may be provided in the cleaning apparatus **10** without departing from the spirit and scope of the invention. In an exemplary embodiment, each brush drum is approximately 2-1/2 to 3 feet in diameter and approximately 6 feet in length. Turning now to Fig. 4, there is shown an alternative embodiment brush head assembly **60"** again having a back plate **68"** with two pairs of laterally extending brackets **70"** between which are rotatably mounted two brush drums **64"**. A monitoring device **74** such as a sensor, a motion detector, or a camera is mounted on the brush head assembly **60"** so as to monitor the movement of the brush head assembly **60"** as it is positioned against and cleans the ship hull **102** (Fig. 1). It will be appreciated by those skilled in the art that the monitoring device **74** may be connected to a control device (not shown) such as a computer or processor to provide the control device with the real-time information needed to control the hydraulic cylinders **48**, **72** (Figs. 1 and 2), and thus the articulated arm **40"**, in dynamically and automatedly positioning the brush head assembly **60"**. In the exemplary embodiment shown, the monitoring device **74** is mounted on an angled plate **76** extending from the top edge **78** of the back plate **68"** so as to be generally aimed toward the area directly in front of the brush drums **64"**, though it will be appreciated that the monitoring device **74** may be mounted in numerous other locations on or about the brush head assembly **60"** or articulated arm **40"**. Referring still to Fig. 4, there is also shown a pressure nozzle **80** mounted on the brush head assembly **60"** and positioned so as to selectively direct a pressure spray toward the ship hull **102** (Fig. 1) substantially adjacent to the brush head assembly **60"**. As explained more fully below, the pressure spray serves to clean the debris loosened by the brush drums **64"** from the area of the ship hull **102** being cleaned. This action of the pressure nozzle **80** would not only then complete the cleaning process in cooperation with the brush drums **64"**, but would also clear away the cleaned area for more accurate monitoring of the brush head assembly **60"** by the monitoring device **74**. As shown in the exemplary embodiment, the pressure nozzle **80** may be mounted on a plate **82** extending from a side edge **84** of the back plate **68"**, though it will be appreciated by those skilled in the art that the pressure nozzle **80**, like the monitoring

device **74**, may be mounted in numerous other locations on or about the brush head assembly **60"** or articulated arm **40"** so as to be directed toward the area of the ship hull **102** (Fig. 1) being cleaned. A wire **88** running from the monitoring device **74** and a line **86** carrying water or other cleaning fluid from a source (not shown) on the cleaning apparatus **10** or carrier **90** to the pressure nozzle **80** may be staked to and run along the articulated arm **40"** so as to be secured out of the way. It will be appreciated that the pressure for the fluid in the line **86** and sprayed from the nozzle **80** may be supplied by the same power source (not shown) used to supply the hydraulic pressure to the hydraulic systems of the cleaning apparatus **10**. The nozzle **80**, like the monitoring device **74**, may also be controlled by a computer or processor control device (not shown) so as to automate and control the entire operation of the cleaning apparatus **10** of the present invention without human involvement, making the apparatus efficient and safe.

Please replace the paragraph beginning on page 16 at line 1 with the following amended paragraph:

In use, the cleaning apparatus **10** is first located adjacent to a ship **100** to be cleaned. When the apparatus **10** is installed on a carrier **90** such as a boat, the apparatus may be brought to the ship **100**, rather than bringing the ship **100** to the cleaning apparatus **10**, enabling the cleaning of a ship anchored at sea or in a harbor far from a dock or pier. This is particularly advantageous for cleaning large tankers and cargo ships that are not easily, and sometimes not possibly, brought in to port. Even when installed on a land mass, pier, dock, or land vehicle, the cleaning apparatus **10** of the present invention serves the beneficial purpose of cleaning a ship hull **102** without having to take the ship **100** out of the water, thereby avoiding the expense and inconvenience of dry docking the ship **100** to clean it. Once the cleaning apparatus **10** is located adjacent to the ship **100**, a stand-off arm **26** mounted on the apparatus **10** is extended laterally outwardly so as to contact the ship hull **102** above the water line and thereby safely space the apparatus **10** from the ship **100**. Because the ship **100** and the carrier **90**, even anchored, will be bobbing in the water and moving relative to one another during cleaning, the stand-off

arm **26** is further provided with a roller **28** on its distal end so as to make rolling contact with the ship hull **102** and further protect it. Multiple stand-off arms **26** may also be provided to better keep the ship **100** and the carrier **90** spaced safely from each other along their respective entire lengths. With the apparatus **10** thus safely positioned adjacent to the ship **100**, the cleaning process can begin. The articulated arm **40** is maneuvered into the water between the carrier **90** and the ship **100** so as to generally orient the brush head assembly **60** toward the underwater portion of the ship hull **102**. In the preferred embodiment, the location of the brush head assembly **60** relative to the ship hull **102** is monitored in real time through a monitoring device **74** such as a sensor, motion detector, or camera. This real-time positioning data can be provided to a control device (not shown) such as a computer or processor, which control device may then in automated fashion control the movement of the articulated arm **40** by specifically controlling the hydraulic cylinders **48** installed along the arm about the hinge connections **44** between the arm's members **42**. In this way, a control loop is established between the monitoring device **74** and the control device so as to dynamically manipulate the articulated arm **40** through the hydraulic system. It will be appreciated that numerous types and configurations of such control loop systems may be employed in the present invention for providing automation of the movement and positioning of the articulated arm **40**. Through such real-time, dynamic control and manipulation, the brush head assembly **60** is ultimately brought into contact with the underwater portion of the ship **102** as shown in Fig. 1. Such positioning may be further aided by rotation of the apparatus **10** relative to the carrier **90** about its rotatable base **22** mounted on the carrier **90** so as to cooperate with the articulated arm **40** in contacting the hull **102** with the brush head assembly **60**. Once the brush head assembly **60** is so positioned, the brush drums **64** are then rotated against the ship hull **102** to remove unwanted foreign objects that impair the movement and performance of the ship, such as sea grasses, tubeworms, barnacles, and the like. To enhance the cleaning performance of the brush drums **64**, the drums **64** are configured within the brush head assembly **60** to be rotated in a direction opposite the direction of travel of the brush head assembly **60** over the surface of the ship hull **102**.

Like the positioning of the brush head assembly **60**, the cleaning of the ship hull **102** by the brush head assembly **102** is also monitored by the monitoring device **74**. The feedback from the monitoring device **74** to the computer or processor control device (not shown) enables the further automation of the cleaning process by allowing the control device to assess the cleaning progress and adjust the location of the brush head assembly **60** accordingly through the hydraulic system of the articulated arm **40**, as explained above. In addition to the positioning data provided by the monitoring device **74**, a device such as a sensor may perform the further feedback function of providing data regarding the pressure of the brush head assembly **60** against the ship hull **102** so as to effectively clean the hull with minimal damage. In the preferred embodiment, the computer or processor (not shown) is linked to and controls both the hydraulic system of the articulated arm **40** and ~~the~~ hydraulic drives ~~66~~ **(not shown)** of the respective brush drums **64** so as to optimally control not only the brush head assembly **60** location, but the speed and direction of rotation of the individual brush drums **64** in conjunction with the movement of the brush head assembly **60** and the overall cleaning progress being made. To further improve the cleaning and monitoring processes, the ship hull cleaning apparatus **10** of the present invention is configured with a pressure nozzle **80** mounted on or about the brush head assembly **60"** so as to selectively spray the area of the ship hull **102** adjacent to the brush head assembly **60"** with a pressurized spray of water or other cleaning fluid. This pressure spray cleans the debris loosened by the brush drums **64"** from the area of the ship hull **102** being cleaned so as to both improve the cleaning process in cooperation with the brush drums **64"**, but also clear away the cleaned area for more accurate monitoring of the brush head assembly **60"** by the monitoring device **74**. For optimal performance of the cleaning apparatus **10**, the pressure nozzle **80** is also controlled by the computer or processor (not shown) so as to coordinate all phases of the cleaning operation based on the real-time data received from the monitoring device **74**. As such, the power source (not shown) that may be installed on the apparatus **10** or carrier **90** so as to provide pressure to both the hydraulic systems, including the hydraulic cylinders **48**, **72**, and the pressure nozzle **80** is also optimally controlled by the control

device in conjunction with the other elements of the overall cleaning apparatus **10**. It will be appreciated that during such use of the cleaning apparatus **10** the weight and movement of the articulated arm **40** will cause an uneven weight distribution about the carrier **90**, which imbalance may be further effectuated by the pressure exerted by the articulated arm **40** through the brush head assembly **60** against the ship hull **102**. To counterbalance this effect and prevent a carrier **90** such as a boat or land vehicle from capsizing or any other non-moving carrier from being subjected to extreme torsional or bending forces during operation of the articulated arm **40**, the counterweight **24** installed on the support frame **20** of the cleaning apparatus **10** substantially opposite of the articulated arm **40** is shifted along the frame **20** so as to counterbalance or offset the articulated arm **40** during use. The movement of the counterweight **24** in offsetting the movement of the articulated arm **40** is optimally and dynamically achieved by also being under the control of the computer or processor control device (not shown). It will thus be appreciated by those skilled in the art that the cleaning apparatus **10** of the present invention provides a safe and efficient system involving no divers or other human involvement in the function of cleaning an underwater ship hull **102**. This automated process, including real-time monitoring of the cleaning progress and adjustment of the cleaning head **60** against the ship hull **102** accordingly, results in a complete swath being cleaned. Moreover, it will be appreciated that the great degree of flexibility and reach of the articulated arm **40** allows the apparatus **10** to clean ship hulls of virtually any size and shape automatically, without any manual adjustments or other retooling or retrofitting of the cleaning apparatus **10**.